IND320 CA3 Ivar Eftedal

Use of AI

- I also used a bunch of AI in this assignment. It was mostly used to create the functions in the jupiter notbook as well as the plots. The first fucntion i did mostly by just following the docs that was provided by the elhub api and made som small and logical tweaks to get all the data stored in the dataframe that was necesarry. So for that part there was very little to no AI usage. For making the plots and lables for the plots AI was used. AI was also used as an sort of assurance, where i would start the tasks myself, and when i though i had a solid result i would ask ChatGPT if i had completely fulfilled all of the requirements. Sometimes it then said that there were certain things i had missed, and then helped me implement these tasks. Just like the previous assignment i only used the free version of ChatGPT.
- The AI usage for the streamlit page was more limited as i already had a bunch of the funcitons from the jupiter notebook. What i did use it for though was to split up one of the funcions that i had in the jupiter notbook. My function: detect_weather_anomalies did plot both of the Outlier/SPC and Anamoly/LOF in the same plot, which meant they were both plotted on both tabs. So i made chatgpt split them up so they could be plotted seperately for their own tabs.

Log of compulsary work

- I started reading up on the docs of the elhub api, and found a very nice example of how they fetch the data in python. This is how i started my code. All i really had to to is to alter the url for the api data and add some extra rows to make sure i got all the data that was needed. This went pretty smoothly. From here on after this i needed more help from AI. I dont think i have ever heard of the Direct Cosine Transfer or SATV, neither the DCT or the LOESS. So here i went to ask AI for answers. I think it was cool to get to fetch and process data from an API and display this in a format that is useful. I like this assignment as most of the time was spent coding.

Experience with jupiter notebook and streamlit

- It was easier to use notebooks than previously. It is still somwhat buggy when i scroll, but at least apart from that things work as expected wihtout having to fix stuff all the time. All cells run as they should and the outputs work as well. I have not had to make any changes to the notebook setup this time. Streamlit was still the same, nicely documented and works just fine. So it was nice to work on this assignment and be able to mostly code and not have to spend time fixing IDE's or installing and linking dependencies. (:

Links:

- GitHub
- https://github.com/ioeftedal/ind320ioeftedal
- Streamlit
- https://ind320ioeftedal.streamlit.app

Getting into the code:

Import dependencies

```
import openmeteo_requests
import requests_cache

import pandas as pd
import matplotlib.pyplot as plt
import numpy as np

from retry_requests import retry
from pygments.lexers import go
from scipy.fftpack import dct, idct
from statsmodels.tsa.seasonal import STL
from sklearn.neighbors import LocalOutlierFactor
from scipy.signal import spectrogram
```

Function for API dowload

```
# Setup the Open-Meteo API client with cache and retry on error
cache_session = requests_cache.CachedSession('.cache', expire_after =
3600)
retry_session = retry(cache_session, retries = 5, backoff_factor =
0.2)
openmeteo = openmeteo_requests.Client(session = retry_session)

def save_data(latitude: float, longitude: float, year) ->
pd.DataFrame:
    # Make sure all required weather variables are listed here
    # The order of variables in hourly or daily is important to assign
them correctly below
    """ Change the url to fetch the data we need"""
    url = "https://archive-api.open-meteo.com/v1/era5"
    params = {
        "latitude": latitude,
        "longitude": longitude,
        "hourly": [
            "temperature_2m",
            "precipitation",
            "wind_speed_10m",
            "wind_gusts_10m",
            "wind_direction_10m"
        ],
        "models": "era5",
        "start_date": f"{year}-01-01",
        "end_date": f"{year}-12-31",
    }
    responses = openmeteo.weather_api(url, params=params)
```

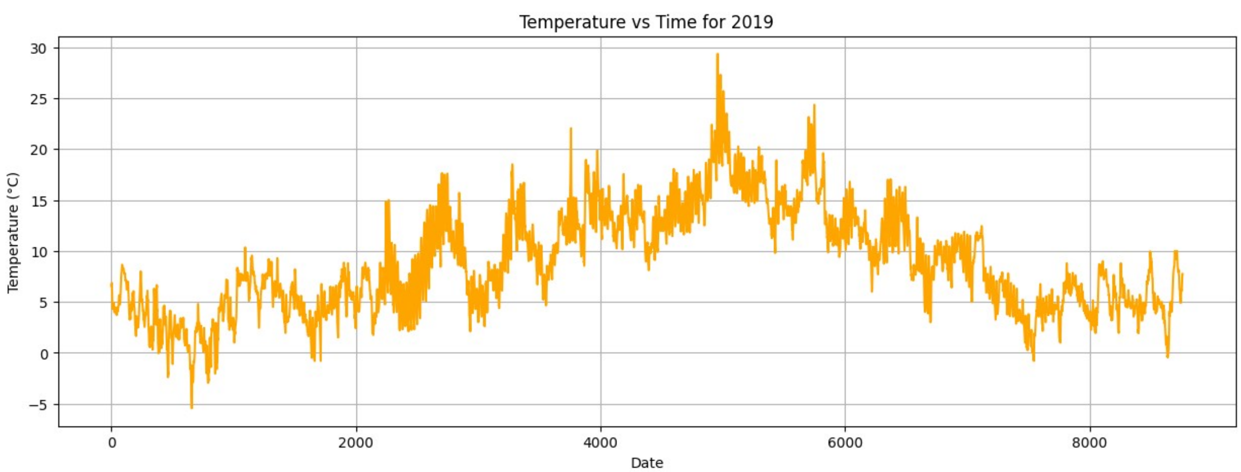
```
    # Process first location. Add a for-loop for multiple locations or
weather models
    response = responses[0]
    print(f"Coordinates: {response.Latitude()}°N
{response.Longitude()}°E")
    print(f"Elevation: {response.Elevation()} m asl")
    print(f"Timezone difference to GMT+0:
{response.UtcOffsetSeconds()}s")

    # Process hourly data. The order of variables needs to be the same
as requested.
    hourly = response.Hourly()
    hourly_temperature_2m = hourly.Variables(0).ValuesAsNumpy()
    hourly_precipication = hourly.Variables(1).ValuesAsNumpy()
    hourly_wind_speed_10m = hourly.Variables(2).ValuesAsNumpy()
    hourly_wind_gusts_10m = hourly.Variables(3).ValuesAsNumpy()
    hourly_wind_direction_10m = hourly.Variables(4).ValuesAsNumpy()

    hourly_data = {"date": pd.date_range(
        start=pd.to_datetime(hourly.Time(), unit="s", utc=True),
        end=pd.to_datetime(hourly.TimeEnd(), unit="s", utc=True),
        freq=pd.Timedelta(seconds=hourly.Interval()),
        inclusive="left"
    ), "temperature_2m": hourly_temperature_2m, "precipication":
hourly_precipication,
        "wind_speed_10m": hourly_wind_speed_10m, "wind_gusts_10m":
hourly_wind_gusts_10m,
        "wind_direction_10m": hourly_wind_direction_10m}

    hourly_dataframe = pd.DataFrame(data = hourly_data)

    return hourly_dataframe
```

Running the function

```
bergen2019 = save_data(60.3929, 5.32415, 2019)

print(bergen2019.head())

plt.figure(figsize=(15,5))
plt.plot(bergen2019.index, bergen2019['temperature_2m'],
color='orange')
plt.xlabel('Date')
plt.ylabel('Temperature (°C)')
plt.title('Temperature vs Time for 2019')
plt.grid(True)
plt.show()
```

```
Coordinates: 60.5°N 5.25°E
Elevation: 17.0 m asl
```

```
Timezone difference to GMT+0: 0s
                       date  temperature_2m  precipitation
wind_speed_10m  \
0 2019-01-01 00:00:00+00:00            6.55            0.5
47.959782
1 2019-01-01 01:00:00+00:00            6.80            0.9
48.621330
2 2019-01-01 02:00:00+00:00            6.85            0.7
52.638840
3 2019-01-01 03:00:00+00:00            6.55            0.6
55.753529
4 2019-01-01 04:00:00+00:00            6.20            1.0
55.531094

   wind_gusts_10m  wind_direction_10m
0       87.839996          277.765076
1       80.279999          296.375275
2       85.320000          310.006195
3       98.639999          314.215271
4      119.519997          317.101654
```

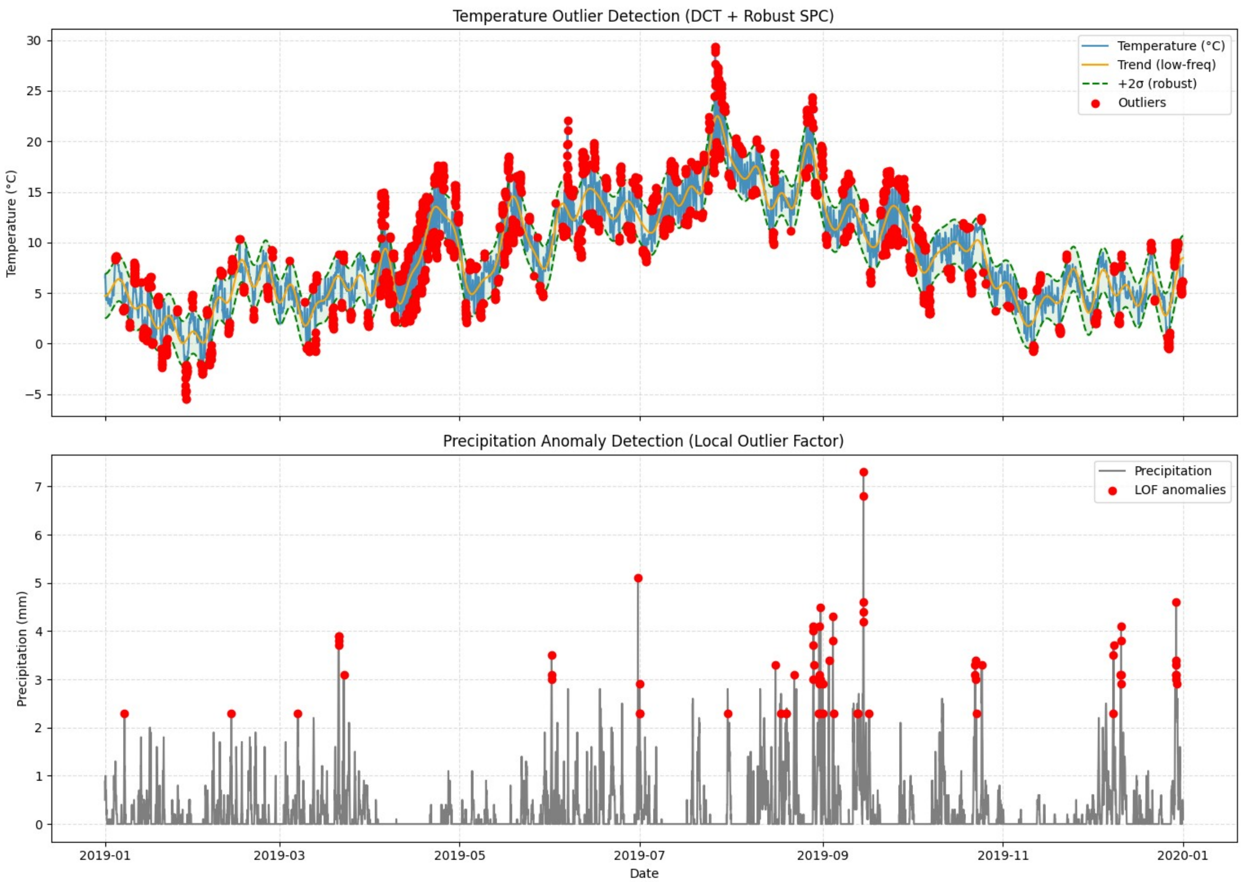



```python
def detect_weather_anomalies(df,
    temp_col='temperature_2m',
    precip_col='precipitation',
    cutoff=100,
    std_mult=2,
    lof_frac=0.01):
    """
    Detect temperature outliers (DCT + SPC) and precipitation
anomalies (LOF).
    """
    df = df.copy()
    df = df.sort_values('date')
    time = pd.to_datetime(df['date'])
```

```
    # Temperature Outliers (DCT + SPC)
    temp = df[temp_col].values
    dct_coeff = dct(temp, norm='ortho')

    # Low-frequency trend
    dct_low = np.copy(dct_coeff)
    dct_low[cutoff:] = 0
    trend = idct(dct_low, norm='ortho')

    # High-frequency component (SATV)
    satv = temp - trend

    # Robust statistics (median + MAD)
    med_satv = np.median(satv)
    mad_satv = np.median(np.abs(satv - med_satv))
    upper_band = trend + std_mult * mad_satv
    lower_band = trend - std_mult * mad_satv

    # Detect outliers
    mask_temp_out = (temp > upper_band) | (temp < lower_band)
    temp_outliers = df.loc[mask_temp_out, ['date', temp_col]]

    # Precipitation Anomalies (LOF)
    precip = df[precip_col].values.reshape(-1, 1)
    lof = LocalOutlierFactor(contamination=lof_frac)
    labels = lof.fit_predict(precip)
    mask_precip_out = labels == -1
    precip_outliers = df.loc[mask_precip_out, ['date', precip_col]]

    # Plot
    fig, (ax1, ax2) = plt.subplots(2, 1, figsize=(14, 10),
sharex=True)

    # Temperature plot
    ax1.plot(time, temp, label='Temperature (°C)', color='tab:blue',
alpha=0.8)
    ax1.plot(time, trend, color='orange', label='Trend (low-freq)')
    ax1.plot(time, upper_band, 'g--', label=f'+{std_mult}σ (robust)')
    ax1.plot(time, lower_band, 'g--')
    ax1.scatter(temp_outliers['date'], temp_outliers[temp_col],
        color='red', label='Outliers', zorder=5)
    ax1.fill_between(time, lower_band, upper_band, color='green',
alpha=0.1)
    ax1.set_title('Temperature Outlier Detection (DCT + Robust SPC)')
    ax1.set_ylabel('Temperature (°C)')
    ax1.legend()
    ax1.grid(True, linestyle='--', alpha=0.4)

    # Precipitation plot
```

```
    ax2.plot(time, df[precip_col], color='tab:gray',
label='Precipitation')
    ax2.scatter(precip_outliers['date'], precip_outliers[precip_col],
        color='red', label='LOF anomalies', zorder=5)
    ax2.set_title('Precipitation Anomaly Detection (Local Outlier
Factor)')
    ax2.set_ylabel('Precipitation (mm)')
    ax2.legend()
    ax2.grid(True, linestyle='--', alpha=0.4)
    ax2.set_xlabel('Date')

    fig.tight_layout()

    summaries = {
        'temperature_outliers': temp_outliers,
        'precip_anomalies': precip_outliers
    }

    return fig, [ax1, ax2], summaries

fig, axes, summaries = detect_weather_anomalies(bergen2019)
plt.show()

# Display outlier summaries
print("Temperature Outliers:")
print(summaries['temperature_outliers'].head())

print("Precipitation Anomalies:")
print(summaries['precip_anomalies'].head())
```

```
/Users/ivareftedal/repositories/github.com/ioeftedal/
ind320ioeftedal/.venv/lib/python3.12/site-packages/sklearn/neighbors/
_lof.py:322: UserWarning: Duplicate values are leading to incorrect
results. Increase the number of neighbors for more accurate results.
  warnings.warn(
```




```
Temperature Outliers:
                        date  temperature_2m
84 2019-01-04 12:00:00+00:00            8.30
85 2019-01-04 13:00:00+00:00            8.45
86 2019-01-04 14:00:00+00:00            8.55
87 2019-01-04 15:00:00+00:00            8.65
88 2019-01-04 16:00:00+00:00            8.65
Precipitation Anomalies:
                          date  precipitation
158  2019-01-07 14:00:00+00:00            2.3
1026 2019-02-12 18:00:00+00:00            2.3
1567 2019-03-07 07:00:00+00:00            2.3
1897 2019-03-21 01:00:00+00:00            3.9
1898 2019-03-21 02:00:00+00:00            3.8
```

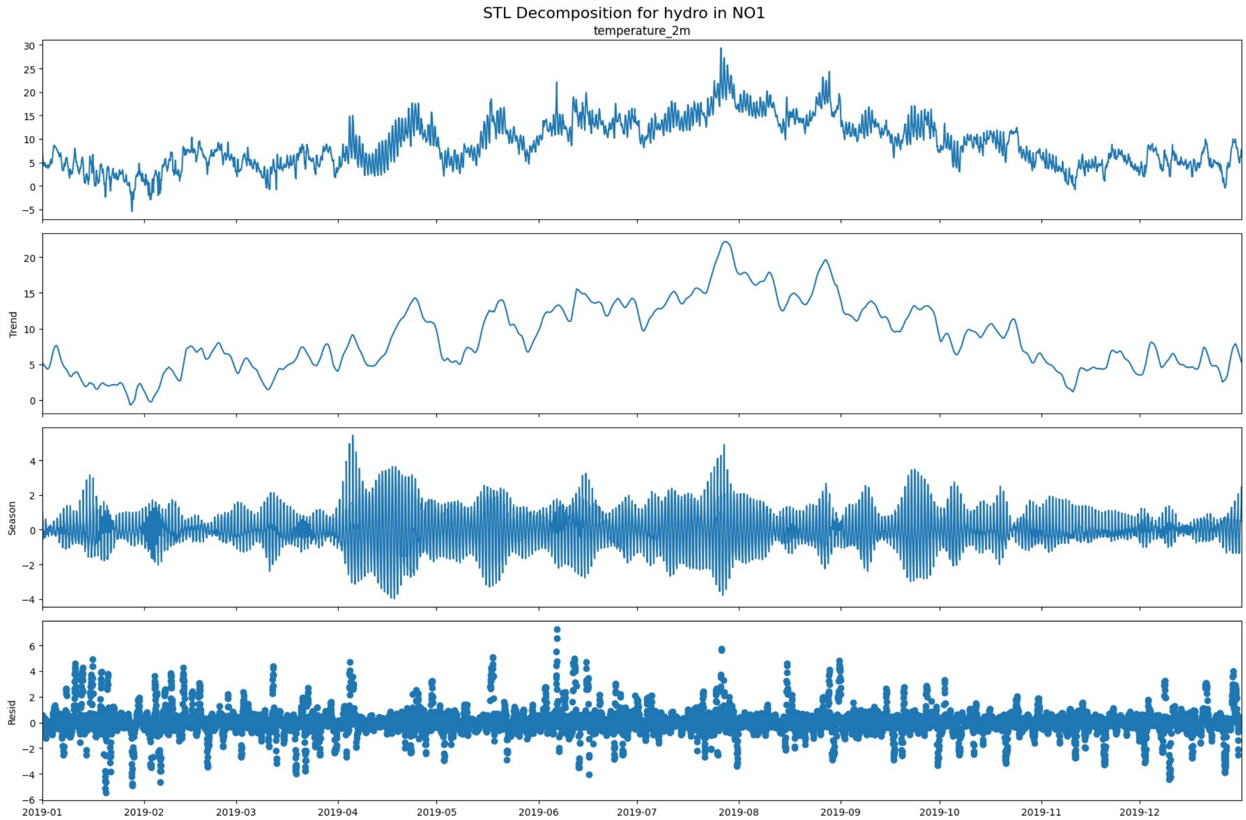
STL Decomposition

```python
def decompose_production_stl(df,
    area='NO1',
    group='hydro',
    period=24,
    seasonal=7,
    trend=73,
```

```
    robust=True,
    figsize=(16, 10)):
    """
    Perform STL decomposition (Seasonal-Trend decomposition using 
LOESS)
    on Elhub production data and plot results.
    """

    # Filter Data (if needed)
    df = df.copy()
    if 'area' in df.columns:
        df = df[df['area'] == area]
    if 'group' in df.columns:
        df = df[df['group'] == group]

    # Assume 'value' is the production measurement column
    value_col = 'value' if 'value' in df.columns else 'temperature_2m'
    df = df.sort_values('date')
    df['date'] = pd.to_datetime(df['date'])
    df = df.set_index('date')

    # STL decomposition
    stl = STL(df[value_col], period=period,
        seasonal=seasonal, trend=trend, robust=robust)
    result = stl.fit()

    # Plot
    fig = result.plot()
    fig.set_size_inches(figsize)
    fig.suptitle(f"STL Decomposition for {group} in {area}", 
fontsize=16)
    fig.tight_layout()

    return fig, result
```

Running the code

```
fig, stl_result = decompose_production_stl(bergen2019, figsize=(18, 
12))
plt.show()
```



Spectrogram

```
def plot_production_spectrogram(df: pd.DataFrame,
    area: str ='NO1',
    group: str ='hydro',
    window_length=256,
    overlap=128):
    """
    Create and plot a spectrogram of Elhub production data.
    """

    df = df.copy()
    if 'area' in df.columns:
        df = df[df['area'] == area]
    if 'group' in df.columns:
        df = df[df['group'] == group]

    value_col = 'value' if 'value' in df.columns else 'temperature_2m'
    df = df.sort_values('date')
    values = df[value_col].values

    #Compute spectrogram
    fs = 1  # sampling frequency (1 sample per hour if hourly)
    f, t, Sxx = spectrogram(values, fs=fs,
    nperseg=window_length,
```

```
    noverlap=overlap,
    scaling='density')

    # Plot
    fig, ax = plt.subplots(figsize=(12, 6))
    pcm = ax.pcolormesh(t, f, 10 * np.log10(Sxx + 1e-12),
        shading='gouraud', cmap='viridis')
    ax.set_ylabel('Frequency [cycles/hour]')
    ax.set_xlabel('Time [samples]')
    ax.set_title(f"Spectrogram of {group} in {area}")
    fig.colorbar(pcm, ax=ax, label='Power (dB)')
    fig.tight_layout()

    return fig, (f, t, Sxx)
```

Running the function

```
fig, (f, t, Sxx) = plot_production_spectrogram(bergen2019)
plt.show()
```